Geoscience Communication gc-2023-1 – Reply on RC2

Referee Comment	**Author Comment**
The work is nicely thought out and well written, and I think this will be useful to add to the literature about how easy users find it to understand uncertainty when presented in different ways. It also nicely demonstrates that different sampling densities would result if the different methods of communicating the uncertainties would be used. I have only very minor comments to add, plus some typos.	We would like to thank the referees for their thorough review of our manuscript. We wish to revise the manuscript based on their suggestions and comments. We reply to each of the comments below. Our suggested edits in the paper are in blue below, with line numbers indicating where we wish to make the changes.
I think the introduction should mention other mapping methods, which can make use of appropriate environmental covariates to model part of the variation, and then justify the focus of the work on kriging and gridded sample designs. If other mapping methods were used, optimal sampling schemes would then not be a grid, could the methods be applied to help in this case?	We have proposed to make changes in the introduction as we were responding to RC1 comments.
14: correlation is bounded on [-1,1]?	Correlations are bounded [-1,1] however, offset correlation ranges from zero (when the maps produced from the two grids are independent of each other (at a coarse spacing) and approach 1 as the grid becomes finer and the two maps become increasingly similar. Therefore, we wish to make the following change in the manuscript from L170 to make it clearer for the reader: The offset correlation is bounded [0,1], and ranges from zero (when the maps produced from the two grids are independent of each other (at a coarse spacing) and approach 1 as the grid becomes finer and the two maps become increasingly similar.
35: Clarify that different grid spacings is for the data (not grid of predictions).	Suggested edit will be made on the manuscript L35:

	Therefore, if we have a reasonable estimate of variance parameters (i.e. variogram for ordinary kriging) we can compute kriging variances for different grid spacings for the data and, in principle, select an acceptable one (McBratney et al., 1981).
42: Should this specifically say “ordinary kriging predictions” (ie not simple/regression/universal kriging)	Suggested edit will be made on the manuscript L35: The kriging variance, at some location, depends only on the variogram and the spatial distribution of observations for ordinary kriging predictions (Webster and Oliver, 2007; Webster and Lark, 2013).
Eq 2: I think z(x0) on right-hand side should be z(xi), also in the text below the equation.	Suggested edit will be made on the manuscript L100 on Equation 2: $$\tilde{Z}(\mathrm{x}_0) = \sum_{\mathrm{I}=1}^{\mathrm{N}} \lambda z(\mathrm{x}_\mathrm{i}),$$ where $z(\mathrm{x}_\mathrm{i})$ is the data and λ are the kriging weights (Webster and Oliver, 2007).
Eq 3: This is a repeat of Eq 1. Probably better here (ie after presenting formula for prediction), so suggest deleting Eq 1.	We propose to delete the following sentence on L97 and equation 1, as suggested by the referee: ~~The kriging variance at the unsampled location, x0, is defined as~~
103: definition of epsilon here should align with what is given on line 112 (probably line 112 version is better).	Suggested edit will be made on L103: Cross-validation predictions of the statistical model need to be examined by exploratory analysis of the error of the kriging prediction, $\varepsilon(x_0)$, defined as $\{\tilde{Z}(x_0) - z(x_0)\}$, to check the if the assumption of normality holds.
134-136: I’m confused by this sentence. If z is 0 in Eq 6, then the true data does not appear in the equation, and the error doesn’t seem to matter, only the value of the prediction?	In the equation the loss is a function of the error, if Z* is the predicted value and the true value is z, then the error is (Z* - z). If the true value is 0 then the error is equal to Z*, that is not the same as saying that the data value has vanished from the error.

162: I think it would be clearer to put “made from data collected on a square grid”	Suggested edit will be made on L162: The expected correlation between the kriging predictions. $\tilde{Z}_1(x_0)$, made from data collected on a square grid, of interval ζ, and predictions, $\tilde{Z}_2(x_0)$, made from a second grid, a translation of the first grid by $\zeta/2$ in both directions is known as the offset correlation.
230: Was the size of blocks the same for all grids, or was it set to be the same size as the grid? The second option (block size = grid size) doesn’t really make sense to me in this context, as the meaning of the predictions (and their variances) would be different for the different sample designs.	We used the same size of blocks for all the grids, and it was 0.01 km^2 square block, and we wish to make the following change in the manuscript on L230. We then computed the cell-centred block kriging variance the spacings we were considering by block kriging (Webster and Oliver, 2007). For all the grid spacings, we computed cell-centred block kriging variance on 0.01 km^2 square blocks.
Fig 4: Can brief details of how these maps be added? Were data for a pair of offsetted sampling grids jointly simulated, then those simulated data (for each of the two offsetted grids in turn) used to predict on the fine-scale mapping grid (as shown in the figure)?	The maps were generated to allow the participant to visualize what two spatial variables correlated by some specified amount would look like. They were generated as realizations of two coregionalized variables with the same mean and variance and the target correlation specified.
450: Needs a sentence added here to summarise what you did (before talking about responses in the next sentence).	We have added the following sentence from L450 as suggested by the referee: In this study we evaluated four methods of communicating uncertainty associated with kriging predictions made from data from a geostatistical survey, to determine an appropriate sampling density to meet stakeholders expectations.
Tables A2 and A3: these could easily be combined into one table	Tables A2 shows the subtable for responses when pooled within the variable used (soil pH and Se_{grain}) when partitioning the full table as illustrated on Table 2. Then table A3 shows the pooled counts of response for offset correlation after all the partitioning for Q1, and this was used to examine if the responses were uniformly distributed.

Line number: suggested new text: 7: “from data on sample grids…”	Suggested edit will be made on the manuscript L7: Offset correlation is a measure of the consistency of kriging predictions made from data on sample grids with the same spacing but different origins
Line number: suggested new text: 20: “concentrations”	Suggested edit will be made on the manuscript L20: In the GeoNutrition project, it has been shown that concentrations of micronutrients in staple crops and in soils vary spatially and so interventions to address the deficiencies should be based on spatial information (Gashu et al., 2021; Botoman et al., 2022).
Line number: suggested new text: 26: “survey efforts”	Suggested edit will be made on the manuscript L26: Often survey efforts are constrained by budgets and we need a trade-off between sample effort and reducing uncertainty.
Line number: suggested new text: 33: “is quantified”	Suggested edit will be made on the manuscript L33: In geostatistical prediction, the variogram function models the spatial dependence of the variable of interest, and the uncertainty in the predicted values is quantified by the kriging variance (i.e., the mean squared error of the prediction).
Line number: suggested new text: 53: “tied to particular decisions”	However, we know that prediction intervals are not preferred by end-users as a method of communicating uncertainty when making decisions, they find it easier to interpret measures of uncertainty tied to particular decisions (Chagumaira et al., 2021).
Line number: suggested new text: 61: delete comma after x0	Suggested edit will be made on the manuscript L61: For a conservative measure of uncertainty, x_0 may be at a general location where uncertainty is largest e.g., at the centre of a square grid cell.
Line number: suggested new text:	Suggested edit will be made on the manuscript L67:

67 “to an acceptable”	The conditional probabilities can then be used to make a decision about soil sampling, by selecting an appropriate grid spacing which limits the risk to an acceptable level.
Line number: suggested new text: 79: “or from a comparable region”	Suggested edit will be made on the manuscript L79: The logistical model can be obtained from data from a previous survey or from a comparable region.
Line number: suggested new text: 138: “reduces the error”	Suggested edit will be made on the manuscript L138: Increasing sample size reduces the minimum expected loss in so far as it reduces the error variance.
Line number: suggested new text: 139: “an additional sample point”	Suggested edit will be made on the manuscript L139: Therefore, the cost of obtaining *n* samples can be measured at which the marginal cost of an additional sample point.
Line number: suggested new text: 145: “the sampling exercise”	Suggested edit will be made on the manuscript L145: The implicit loss function is conditional on a logistic model, that expresses the marginal costs of the sampling exercise
Line number: suggested new text: 149: “number of samples”	Suggested edit will be made on the manuscript L149: where $\bar{n}$ is the specified number of samples, C(n) is the function that returns the cost of n samples and ϕ is a vector of variogram
Line number: suggested new text: 155: “denotes”	Suggested edit will be made on the manuscript L155: Where, F^{-1} denotes the quantile of the prediction distribution for a probability P_0 obtained from
Line number: suggested new text: 158: “loss functions”	Suggested edit will be made on the manuscript L158: Lark and Knights (2015) suggested that a stakeholder group might consider an implicit loss function for different $\bar{n}$ starting points in the

	elicitation of a sample size or compare implicit loss functions for different projects given different partitions of a total budget between them.
Line number: suggested new text: 231: “three different predictions”	Suggested edit will be made on the manuscript L231: We considered three different predictions for each variable, but the prediction interval was fixed, depending only on grid spacing.
Line number: suggested new text: 244: “asked the participant what grid”	Suggested edit will be made on the manuscript L244: We then asked the participant what grid spacing they thought corresponded to the largest acceptable value of this probability.
Line number: suggested new text: 267: “pair of maps”	Suggested edit will be made on the manuscript L267: Figure 4, shows an example of pair of maps of Se_{grain} concentration and the corresponding scatterplot (see Figure S5 and S6).
Line number: suggested new text: 289: “partitioned into components corresponding to a pooled table”. 291: I think “Figure 3” should be “Table 2”	Suggested edit will be made on the manuscript L289 and L291: The full table in Table 2, was partitioned into components corresponding to subtables for soil pH (subtable 1 in Table 2), and Segrain concentration (Subtable 2 in Table 2).
Line number: suggested new text: 302: “differences in responses”	Suggested edit will be made on the manuscript L302: We first tested for differences in responses recorded for each test method, by the variable used (soil pH or Se_{grain} concentration) using contingency tables.
Line number: suggested new text: 311: “no difference”	Suggested edit will be made on the manuscript L311: For some questions, we noted differences in the responses when pooled within variable used (soil pH or Segrain concentration) and there was no difference in responses in professional groups and frequency of use of statistics for all
Line number: suggested new text:	Suggested edit will be made on the manuscript L312:

312: “were uniformly”	We further analysed the pooled tables or separate subtables to examine if the responses were uniformly distributed and the null hypothesis is a random distribution.
329: “responses of the?” Missing something here.	We have made the following edit on L329: There were no differences in the responses when the columns were pooled by the variable used, soil pH vs. Segrain concentration, p = 0.656 (Table 3).
Line number: suggested new text: 372: I don’t think this should be “by all respondents” (ie not every single respondent ranked it first?), maybe should be “Amongst all respondents, the offset…most effective”	Suggested edit will be made on the manuscript L372: Amongst all the respondents, the offset correlation was ranked as the most effective (Figure 9a) and implicit loss function as the least effective.
Line number: suggested new text: 380: “statistics”	Suggested edit will be made on the manuscript L380: Those who always use statistics, ranked conditional probabilities second.
Line number: suggested new text: 388: “explains why there were”	Suggested edit will be made on the manuscript L388: This explains why there were more consistent responses under this method
Line number: suggested new text: 404: “This suggests”	Suggested edit will be made on the manuscript L404: This suggests that the stakeholders may not have fully understood the method.
Line number: suggested new text: 417: “by the respondents” and “would be of greatest value”	Suggested edit will be made on the manuscript L417: Similar reasons were given by the respondents. We expected that prediction intervals would be of greatest value for specific interpretation of particular sites but would be of limited value for survey planning.

Line number: suggested new text: 432: “beginning” and “explanation of”	Suggested edit will be made on the manuscript L432: At the beginning of the online workshop, we explained each method with the aid of illustrations. After an explanation of each method, there was a feedback session to allow the participants opportunities to seek clarity on ambiguous and unfamiliar concepts from the presenters.
Line number: suggested new text: 441: “different variables”	Suggested edit will be made on the manuscript L441: All the methods may give different results for different variables, because they depend on the variogram of the variable in question.